THE ROLES OF SMART TECHNOLOGIES IN ARCHITECTURAL TRAINING IN NIGERIAN UNIVERSITIES: CASE STUDY APPROACH IN SOUTH- SOUTH

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ABSTRACT

The integration of smart technologies into architectural education has emerged as a pivotal factor in aligning academic training with global professional standards. This study investigates the role of such technologies in architectural training within selected universities in Nigeria's South-South region, focusing on the University of Uyo, University of Port Harcourt, and Niger Delta University. Using a qualitative case study approach, data were collected through semi-structured interviews with faculty and final-year students, document reviews, and on-site observations of teaching facilities. Analysis was guided by the Technology Acceptance Model and the Diffusion of Innovations theory, enabling an understanding of both individual and institutional adoption behaviours. Findings indicate partial but uneven integration of tools such as Building Information Modelling (BIM) and Virtual Reality (VR), with clear benefits in enhancing design visualisation, collaborative learning, and professional readiness. However, adoption is constrained by infrastructural deficiencies, high software costs, limited faculty training, and rigid curricula. The study recommends targeted investment in digital infrastructure, structured faculty development programmes, and curriculum reforms to embed smart technologies as core learning outcomes. These measures are essential for producing graduates equipped to address the evolving demands of the architectural profession in Nigeria and beyond.

KEYWORDS: **Smart technologies, architectural education, Building Information Modelling, Virtual Reality, Technology Acceptance Model, Diffusion of Innovations, South-South Nigeria.**

INTRODUCTION

Architectural education in Nigeria has undergone significant evolution over the past five decades, transitioning from a predominantly manual, studio-based model to the gradual adoption of digital tools, computational methods, and globally informed pedagogical practices. In its early years, the training of architects in Nigerian universities was deeply rooted in traditional design pedagogy, which placed emphasis on hand-drawn drafting, manual rendering, and the creation of physical models as the primary modes of exploration and communication of design ideas. Studio sessions were characterized by direct, face-to-face critiques, with design knowledge passed on through close mentorship between students and lecturers. At that stage, technological integration was minimal, often limited to basic drafting aids or presentation tools, and was largely viewed as supplementary rather than transformative.

However, the global architectural landscape has shifted dramatically in recent decades due to the rapid advancement of digital infrastructure, the growing demand for sustainable and performance-driven design, and the increasing complexity of construction projects. This has triggered a paradigm shift in architectural training, where proficiency in digital tools is no longer optional but central to professional competence. For Nigerian universities particularly those training architects for both local and international practice this transition has brought about the need to rethink curricula, upgrade facilities, and adopt innovative teaching methodologies that prepare graduates for a competitive, technology-driven industry.

Within this evolving framework, the term *smart technologies* encompasses a suite of advanced computational and interactive tools that enhance the processes of design, visualization, analysis, and collaboration. These include, but are not limited to, Building Information Modelling (BIM) platforms for integrated design and documentation; Internet of Things (IoT) frameworks for real-time building performance simulations; Artificial Intelligence (AI) algorithms for generative, predictive, and performance-based design; and immersive technologies such as Virtual Reality (VR) and Augmented Reality (AR) for experiential spatial visualization. Cloud-based collaboration platforms, parametric design software, and environmental simulation tools also fall within this category. Collectively, these technologies have redefined architectural education globally, enabling students and practitioners to create more responsive, sustainable, and innovative built environments.

In the Nigerian context, and more specifically within the South-South geopolitical zone, universities such as the University of Uyo, Niger Delta University, and the University of Port Harcourt are increasingly aware of the value of incorporating smart technologies into architectural curricula. These institutions recognize that such integration not only improves the quality of design education but also enhances employability, fosters creativity, and aligns academic outcomes with contemporary professional expectations. Nevertheless, adoption has been uneven and often hindered by systemic challenges. These include limited access to reliable digital infrastructure, inadequate funding for hardware and software acquisition, inconsistent internet connectivity, and gaps in faculty training and expertise. Furthermore, institutional resistance to pedagogical change, coupled with a lack of locally tailored strategies for integrating these technologies, has contributed to the slow pace of transformation.

This reality presents a dual narrative: on one hand, there is the challenge of bridging the digital divide between Nigerian architectural schools and their counterparts in more technologically advanced regions; on the other, there lies the opportunity to localize and adapt smart technologies in ways that respond to Nigeria's unique environmental, socio-economic, and infrastructural realities. Leveraging such opportunities could allow architectural education in the region to not only catch up with global trends but also lead in developing contextually innovative solutions.

THEORETICAL FRAMEWORK

This study draws on two complementary theoretical models the Technology Acceptance Model (TAM) and the Diffusion of Innovations (DOI) Theory to provide a structured understanding of how smart technologies are perceived, adopted, and integrated into architectural training in Nigerian universities, particularly within the South-South region. While TAM focuses on the individual-level factors influencing technology adoption, DOI addresses the broader social and institutional processes by which innovations spread within an academic environment. Together, these frameworks create a multi-layered analytical lens for interpreting the adoption of smart technologies in architectural education.

- **Technology Acceptance Model (TAM)**

  The Technology Acceptance Model, developed by Fred D. Davis in 1989, is a foundational framework for explaining technology adoption. It posits that two main factors Perceived Usefulness (PU), and Perceived Ease of Use (PEOU) shape an individual's intention to use a technology, which subsequently predicts actual adoption. Perceived usefulness refers to the degree to which a person believes that using a specific technology will improve their performance in a particular context. In architectural education, this relates to whether students and lecturers consider tools such as Building Information Modelling (BIM), Virtual Reality (VR), Augmented Reality (AR), or Artificial Intelligence (AI) applications to be capable of improving design accuracy, enhancing creativity, reducing repetitive manual tasks, or enabling more realistic spatial presentations. When these benefits are clear and tangible, adoption becomes more likely. However, if the technology's relevance to design learning and professional practice is not apparent, uptake tends to be slow, regardless of availability. Perceived ease of use, on the other hand, is concerned with how effortless a technology is perceived to be. In the South-South Nigerian university context, this perception is shaped by factors such as the complexity of the software, the availability of user training, the compatibility of the technology with existing curricula, and the reliability of supporting infrastructure such as electricity and internet connectivity. Even when a tool is highly beneficial, it may face low adoption if it is considered too complex to master, too demanding in terms of hardware requirements, or too incompatible with existing teaching approaches.

- **Diffusion of Innovations (DOI) Theory**

  Proposed by Everett Rogers (2003), the Diffusion of Innovations Theory explains how new ideas, practices, or technologies spread within a social system over time. The model identifies five stages in the adoption process Knowledge, Persuasion, Decision, Implementation, and Confirmation and categorises adopters into Innovators, Early Adopters, Early Majority, Late Majority, and Laggards, the DOI theory is in different stages of adoption.

  - Knowledge: Awareness of the existence of a technology. In universities, this may come through workshops, guest lectures, or exposure via industry collaborations.
  - Persuasion: Forming an attitude toward the technology based on observed benefits or peer influence.
  - Decision: Choosing whether to adopt the technology, often influenced by institutional policies or peer recommendations.
  - Implementation: Actively using the technology in studio projects, research, or classroom instruction.
  - Confirmation: Continuing usage based on positive results, feedback, and reinforcement from peers or supervisors. In Nigerian architectural schools, students may first encounter BIM or VR through industry-sponsored seminars (knowledge stage), become impressed by its design capabilities (persuasion), and decide to use it for their studio project (decision). If the process improves their design quality and presentation outcomes (confirmation), adoption becomes more sustained. There are different categories of Adopters.
  - Innovators: Technologically curious faculty or students who are eager to try out new tools as soon as they become available.
  - Early Adopters: Influential figures in the academic community who quickly recognise the value of a new technology and promote its use.
  - Early Majority: Those who adopt once the technology has been proven effective in their immediate environment.

- Late Majority: Those who are cautious, adopting only after most of their peers have embraced the technology.
- Laggards: Those who resist adoption due to entrenched traditional practices, lack of resources, or scepticism about the benefits.

Integrating TAM and DOI for this Study

The integration of TAM and DOI offers a richer understanding of technology adoption in architectural education than either model could provide alone. TAM focuses on the internal cognitive and affective factors perceived usefulness and ease of use that influence individual decisions to adopt smart technologies. DOI situates these decisions within a larger network of social interactions, institutional structures, and cultural norms that either accelerate or slow the spread of innovation.

Applied together in the South-South Nigerian context, these models reveal how the personal attitudes of lecturers and students interact with systemic factors such as infrastructure readiness, funding policies, curriculum design, and peer influence. For example, a lecturer may find BIM highly useful and easy to learn (TAM), but if the institution lacks adequate computer labs or most colleagues are sceptical (DOI), the overall rate of adoption may remain slow. Conversely, when early adopters demonstrate clear benefits in a supportive environment, the combined effect of positive perception and institutional reinforcement can create a tipping point for widespread acceptance.

By grounding this study in both TAM and DOI, the research can capture the complexity of smart technology adoption in architectural training. It recognises that the process is shaped not only by individual willingness but also by the collective dynamics of universities operating within the socio-economic and infrastructural realities of Nigeria's South-South region.

METHODOLOGY

This study adopted a qualitative case study design to explore the extent, and way smart technologies are integrated into architectural training within the South-South region of Nigeria. The choice of a case study approach was informed by the need to investigate the phenomenon in its natural setting and to capture the institutional, pedagogical, and infrastructural contexts influencing technology adoption. Three universities were purposively selected based on their accreditation status, location, and the availability of architecture programmes: the University of Uyo (UNIUYO) in Akwa Ibom State, Niger Delta University (NDU) in Bayelsa State, and the University of Port Harcourt (UNIPORT) in Rivers State. These institutions provided a spectrum of experiences ranging from emerging integration efforts to relatively established technology use in teaching and learning.

DATA COLLECTION

The study employed three complementary data collection techniques to enhance validity through methodological triangulation. First, semi-structured interviews were conducted with a total of 42 participants, comprising 12 faculty members (four from each institution) and 30 final-year architecture students (ten from each institution). The interviews sought to capture perceptions, experiences, and attitudes toward the integration of smart technologies such as Building Information Modelling (BIM), Virtual Reality (VR), Artificial Intelligence (AI)-driven design tools, and Internet of Things (IoT) applications. Open-ended questions allowed participants to elaborate on challenges, training experiences, and perceived impacts on learning outcomes.

Second, curriculum review involved the systematic analysis of departmental course outlines, programme structures, and accreditation reports. The objective was to identify the presence and positioning of smart technology-related modules within the curriculum, including whether such content was offered as core courses, electives, or embedded within broader design studio courses. Attention was also given to the depth of content and whether learning outcomes explicitly referenced technology competencies.

Third, direct observation was carried out in each institution to document the physical availability and condition of relevant facilities. This included the assessment of BIM laboratories, VR studios, computer-aided design suites, and, where present, digital fabrication workshops equipped with 3D printers or CNC machines. Observations also covered patterns of facility use during lectures, studio sessions, and independent student work periods. Field notes and photographs (where permitted) were used to record the findings.

DATA ANALYSIS

Data were analysed using thematic analysis, guided by Braun and Clarke's (2006) six-phase framework: familiarisation with the data, generation of initial codes, search for patterns, review of emerging themes, definition of final themes, and report writing. The process was supported by NVivo 12 software, which facilitated systematic coding and organisation of the qualitative data. Codes were derived inductively from the data rather than imposed a priori, ensuring that emerging themes authentically reflected the participants' narratives and observed realities. Patterns were then compared across institutions to identify similarities, differences, and institutional-level determinants of adoption.

ETHICAL CONSIDERATIONS

Ethical clearance was secured from the Research Ethics Committees of the three participating institutions prior to data collection. Participants were provided with detailed information sheets outlining the study's aims, methods, and intended use of findings. Written informed consent was obtained from all respondents, and participation was entirely voluntary. Anonymity was preserved by using coded identifiers instead of names, and data were stored securely in password-protected files accessible only to the research team. Special care was taken during observation sessions to avoid disrupting ongoing teaching and learning activities.

FINDINGS AND DISCUSSION

The findings are presented thematically to reflect the key patterns that emerged from the data analysis, linking the interview narratives, curriculum reviews, and field observations. Each theme is discussed in relation to the theoretical framework, highlighting the interplay between individual perceptions (Technology Acceptance Model) and institutional adoption patterns (Diffusion of Innovations theory). Across the three case study universities, the integration of smart technologies into architectural training was uneven and, in most cases, partial. At UNIUYO, the curriculum included explicit references to Building Information Modelling (BIM) within the "Advanced Architectural Design" and "Sustainable Design" courses. However, interviews revealed that the coverage was primarily theoretical due to the limited number of high-performance computers capable of running advanced BIM features. Observations confirmed that only 10 out of the 24 workstations in the department's CAD laboratory met the recommended system requirements for BIM platforms such as Autodesk Revit. Students reported relying on personal laptops and student-license versions of software, which often restricted them to basic modelling functions.

UNIPORT demonstrated the most visible investment in smart technologies among the three institutions. The Faculty of Environmental Sciences operated a dedicated BIM laboratory and had recently piloted a Virtual Reality (VR) initiative. During observation sessions, students were seen engaging in immersive walkthroughs of their studio projects using a VR headset connected to a high-specification workstation. While this provided an advanced pedagogical experience, faculty interviews indicated that the facility's usage was limited to final-year students due to time constraints and the scarcity of equipment a single VR setup serving over 200 students annually.

In NDU, the integration of smart technologies was minimal. While AutoCAD was taught in the second year, there was no formal curriculum content addressing BIM, VR, IoT applications, or AI-driven design. Observation of the department's facilities showed a small CAD laboratory with desktop computers, most of which were outdated and incapable of supporting resource-intensive software. Faculty members attributed this to chronic underfunding and unreliable electricity supply, which discouraged sustained technology use.

PERCEIVED BENEFITS

Across the three institutions, participants identified clear benefits associated with the use of smart technologies in architectural training. Faculty members at UNIPORT emphasised that BIM improved students' ability to integrate multiple aspects of a project structural systems, environmental performance, and construction sequencing within a single coordinated model. Students at UNIUYO highlighted the visualisation advantage of 3D parametric modelling, which allowed them to better evaluate spatial proportions and material finishes before physical model- making. At UNIPORT, the introduction of VR was described as a "game changer" by students, enabling them to "experience" their designs from a user's perspective and make informed design modifications.

From the perspective of professional readiness, participants noted that familiarity with BIM and VR tools aligned graduates' skills with industry expectations, particularly for firms engaged in complex, multi-disciplinary projects. This was consistent with the Technology Acceptance Model's construct of "perceived usefulness," as both students and faculty expressed strong belief in the capacity of these technologies to enhance design quality and employability.

CHALLENGES TO ADOPTION

Despite these benefits, several structural and institutional constraints hindered full integration.

A recurrent theme was the high cost of proprietary software licenses. All three universities relied on a combination of outdated software versions and free student licenses, which limited access to advanced functionalities such as automated energy analysis, clash detection, and cloud-based collaboration. Faculty members at NDU reported difficulty securing institutional licenses due to budgetary restrictions.

Infrastructural limitations were also significant. In UNIUYO and NDU, frequent power outages disrupted scheduled laboratory sessions, forcing a reliance on personal devices in less-equipped studio spaces. At NDU, interviews with students revealed that some resorted to working off-campus in private business centres equipped with more reliable power supply and internet access. A shortage of trained faculty was evident across all three institutions. Several lecturers, particularly senior staff, were more comfortable with traditional drafting and 2D CAD tools, having received their training before the widespread adoption of smart technologies. This slowed the integration process, as there were few internal champions to lead curriculum reform and mentor students in advanced software use. Curriculum rigidity further constrained adoption. Course outlines, particularly those aligned with ARCON accreditation requirements, were slow to incorporate emerging technologies, meaning that any new content often had to be introduced informally or as optional workshops rather than core learning outcomes.

THEORETICAL LINKAGES

The variation in adoption patterns across the institutions aligns closely with the Diffusion of Innovations theory. UNIPORT's VR initiative represents the early adoption stage, driven by a small group of technologically proficient lecturers who acted as change agents within the institution. UNIUYO's partial integration of BIM reflects the persuasion and decision stages, where awareness and interest exist but structural constraints hinder full implementation. NDU remains largely at the knowledge stage, aware of the existence of these technologies but unable to progress toward implementation due to infrastructural and financial barriers.

From the perspective of the Technology Acceptance Model, "perceived usefulness" was consistently high among students and faculty who had some exposure to smart technologies. However, "perceived ease of use" varied significantly, being highest in UNIPORT (where equipment and training were more available) and lowest in NDU (where infrastructural barriers and lack of exposure reduced confidence in using the tools).

CONCLUSION

The investigation into the role of smart technologies in architectural training within South-South Nigerian universities reveals a sector in transition. While there is widespread recognition among students and faculty of the potential of tools such as Building Information Modelling (BIM), Virtual Reality (VR), and related digital applications, their integration into the teaching-learning process remains partial and inconsistent. The three case study institutions the University of Uyo (UNIUYO), the University of Port Harcourt (UNIPORT), and Niger Delta University (NDU) represent different points on the adoption spectrum, shaped by institutional priorities, resource availability, and the capacity of teaching staff.

UNIPORT demonstrates the highest degree of integration, with visible investment in BIM laboratories and experimental use of VR for design visualisation. UNIUYO has made strides in incorporating BIM into its curriculum, but infrastructural limitations and limited faculty training have slowed full adoption. NDU lags significantly, constrained by outdated hardware, insufficient funding, and inconsistent power supply, leaving its students at a disadvantage in terms of exposure to industry-standard tools.

Across all institutions, the perceived usefulness of smart technologies is high a finding consistent with the Technology Acceptance Model, but perceived ease of use varies, largely determined by the availability of infrastructure, access to training, and supportive institutional policies. The Diffusion of Innovations theory further explains the uneven adoption, as institutions with early adopter champions (notably UNIPORT) are progressing faster, while others remain in the awareness stage without moving into active implementation.

The implications of these findings are significant. In a rapidly urbanising Nigeria, where the construction sector faces increasing demands for efficiency, sustainability, and innovation, producing graduates proficient in smart technologies is no longer optional it is a necessity. Without decisive interventions, South-South universities risk perpetuating a skills gap that undermines both graduate employability and the ability of the architectural profession to contribute effectively to national development goals.

RECOMMENDATIONS

- Strategic Infrastructure Investment: Federal and state governments, through agencies such as the Tertiary Education Trust Fund (TETFund), should prioritise the provision of high-performance computing facilities, stable electricity supply, and high-speed internet connectivity for architecture departments. This includes funding dedicated BIM laboratories, VR studios, and digital fabrication workshops to provide hands-on learning experiences.
- Industry–Academia Partnerships: Universities should actively engage with software vendors, professional bodies such as the Nigerian Institute of Architects (NIA), and leading architectural firms to secure educational licenses, training resources, and industry mentorship programmes. Partnerships could also include equipment donations or subsidised access to advanced software tools.
- Faculty Development Programmes: Continuous professional development is essential to ensure faculty members remain competent in emerging technologies. This could be achieved through sponsorship of lecturers to attend BIM and VR certification courses, structured sabbaticals in technologically advanced architectural firms, annual in-house training workshops facilitated by industry experts.
- Curriculum Reform and Flexibility: The Architects Registration Council of Nigeria (ARCON) and the National Universities Commission (NUC) should review accreditation requirements to allow for faster integration of smart technology competencies into core courses. Curricula should be dynamic, with periodic reviews to incorporate new technological trends without waiting for lengthy bureaucratic approval cycles.
- Phased Implementation Plans: For universities with severe infrastructural limitations, a phased adoption strategy could be implemented, starting with low-cost interventions such as open-source BIM software training and incremental equipment upgrades, before progressing to advanced tools like VR and AI-driven design applications.
- Interdisciplinary Collaboration: Establishing digital design innovation hubs that bring together architecture, engineering, and computer science students can foster cross-disciplinary creativity and broaden the application of smart technologies beyond traditional design studio work.
- Power and Connectivity Solutions: Given the persistent challenges of unreliable electricity and limited internet access, universities should explore alternative power solutions such as solar energy systems for critical laboratories, as well as dedicated broadband lines for teaching facilities.

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